NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ISSUES AND CONCERNS IN INTERNATIONAL CO-DEVELOPMENT EFFORTS

by

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June 2002

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2002	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE: Issues and Concerns in International Co-Development Efforts			**5. FUNDING NUMBERS**
6. AUTHOR(S) Serkan Virlan			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT ***(maximum 200 words)***

After the collapse of Iron Curtain, all nations tried to adapt to the new environment. They could either develop and produce their own weapons systems as before and bear all the associated burden. Or, they could co-operate in various phases of the project, sharing expenses, expertise, technology while creating a market even before the first prototype is built. In this thesis I address the issues and concerns which emerged in projects realized and on going; MEADS (Medium Extended Air Defense System), JSF (Joint Strike Fighter), Eurofighter and FLA (Future Large Aircraft). I will consider whether entering cooperative projects is a useful approach, and if it can be implemented as a solution for Armed Forces modernization. In general this thesis will consider lessons learned from the example projects and apply those lessons to understanding the future environment for international defense cooperation.

14. SUBJECT TERMS Future Large Aircraft (FLA), Eurofighter, Medium Extended Air Defense System, MEADS) Joint Strike Fighter (JSF), Co-Development			**15. NUMBER OF PAGES** 65
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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ISSUES AND CONCERNS IN INTERNATIONAL CO-DEVELOPMENT EFFORTS

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

After the collapse of Iron Curtain, all nations tried to adapt to the new environment. They could either develop and produce their own weapons systems as before and bear all the associated burden. Or, they could co-operate in various phases of the project, sharing expenses, expertise, technology while creating a market even before the first prototype is built. In this thesis I address the issues and concerns which emerged in projects realized and on going; MEADS (Medium Extended Air Defense System), JSF (Joint Strike Fighter), Eurofighter and FLA (Future Large Aircraft). I will consider whether entering cooperative projects is a useful approach, and if it can be implemented as a solution for Armed Forces modernization. In general this thesis will consider lessons learned from the example projects and apply those lessons to understanding the future environment for international defense cooperation.

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I. INTRODUCTION

A. GENERAL

After the collapse of the Iron Curtain, all nations tried to assess an environment in which the probability of a mass conventional attack from one of the super powers is very low. This trend is supported by the operations conducted by NATO or the UN to present day. Governments had seen this period as an opportunity to decrease massive defense budgets and find better ways to spend taxpayer's money. However, historic conflicts, the threat of nuclear, biologic and chemical warheads used with long-range ballistic missiles and differences between policies/national characteristics are still present. These facts have prompted nations to approach carefully the idea of a smaller, lower-cost national defense force. The only choice other than maintaining a large force was investing in technology and newer, more precise weapons. As time went on, and "unusual" operations that were not within the experience or mission statement of organizations such as NATO were conducted, for example in the Balkans, those organizations, as well as individual nations, felt the need to revise their force structures and acquisition strategies. Collateral damage avoidance and stand-off capabilities became essential, even though it was expensive to develop and acquire such capabilities. On the other hand, economically powerful nations no longer had the excuse of conducting a weapons race against another power to justify large expenditures on weapons. Although the need for advanced, expensive weapons systems grew, defense budgets, and with them, existing defense industrial bases shrank, resulting in a loss of competition. Thus, advanced weapons development and acquisition was even more expensive because from then on, some of the effort had to be spent to maintain the industrial base. Therefore, it was time to make a decision. They would either try to develop and produce their own weapon systems as they had done previously and bear the burden of all expenses entailed as well as prove the effectiveness of a system to create a market or they would cooperate in various phases of the project, such as development and production and share the expenses, expertise and technology in order to create a market even before the first prototype is out in the field.

Of course, the latter idea was not without problems. Security, economic and political issues as well as the work share ratios were some of the issues that surfaced instantly.

In addition to these facts, as Raymond E. Franck, Jr. stated in his article "Recent Developments in the Global Defense Marketplace" (Graduate School of Business and Public Policy, Naval Postgraduate School-August 2001), a change in the defense environment is closely related to defense acquisition reform, a revolution in military affairs, the onset of information age economies, and the globalization of economic activities. Of course, it is arguable whether these movements resulted in the recent changes or they are the results of the changes. When movements after the 11th September 2001 terrorist attacks to the World Trade Center buildings, Pentagon and third hijacked plane are taken into consideration, it is possible to come to the conclusion that recent changes cause such revolutions in the defense environment and to see how governments and/or industry are foreseeing the future of the situation. The efficiency provided when nations work together seems to become a priority and it would be expected that countries would be willing to sacrifice some of their national goals for it. Basically, there are two opinions. You are either for or against this expectation. The first is if the nation would be dependent on another country's production for critical items or subcomponents for a weapon system manufactured through a co-development arrangement, and how would national security be affected if a conflict were to occur between the two nations. This idea is also addressed in R. E. Franck's article as the concerns about the growing international trade:

> …expanding international trade has increased economic specialization among nations. This has proven an especially sensitive issue when interdependence means loss of self-sufficiency in military production.

The second opinion basically depends on the idea that conflicts are less likely to occur if a nation is engaged in business relations with another nation. The greatest obstacle to this idea are the "Buy National" acts that exist in almost all legislation in countries worldwide. Both ideas may be supported by some of the arrangements made in co-development projects.

Nations use several ways to protect and improve their national industries, such as non-tariff barriers, off-set arrangements, co-production proposals, strategic partnering arrangements and finally co-development efforts. This thesis will address the issues and concerns raised within the completed and on going co-development projects such as FLA (Future Large Aircraft), Eurofighter, MEADS (Medium Extended Air Defense System), and JSF (Joint Strike Fighter). These are all Acquisition Category I (ACAT I), major weapon systems projects. In addition, I will also address the solutions implemented to overcome the problems and generalize the potential issues that may be raised in typical co-development projects regarding the status of the participating nations as being developed, developing or underdeveloped countries, and their economic as well as political stance. The question of whether this is the correct approach, if it can be implemented as a solution to the modernization effort of a nation's defense forces and simply if the idea is feasible for the future will also be addressed. In general, this thesis will glean lessons learned from the projects selected as examples.

B. METHODOLOGY

The news and documents written about the projects used as examples were researched and chosen from the Internet and library resources. Problems raised during the execution of the project were highlighted and an attempt was made to gather information on the solutions implemented to solve those problems. Then, the problems were generalized by disregarding the specific needs of the specific projects. This was easy since many of the participant nations, and the general situation, was similar in those projects. Nevertheless, the assumption is that the problems raised are more or less applicable to a variety of situations and a combination of participants. It is also assumed that the solutions implemented in those projects are potential solutions that can be used to overcome a tense situation at least as far as the expertise they represent. Lastly, this thesis emphasizes the future of international co-development efforts so that they will be inevitable practices regarding the environment analysis made in this thesis.

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II. REVIEW OF THE SELECTED PROJECTS

A. FUTURE LARGE AIRCRAFT (FLA-A400M)

Recent operations have shown mobility to be one of the most important capabilities of a force. The Gulf War and the operations in Kosovo and Afganistan demonstrated that the Armed Forces are extremely dependent on air transport. However, many countries also realized the urgent need to modernize their aging transport fleets which in European countries consists mostly of the C-130 Hercules and C-160 Transall aircraft. Since 1982, different groups, including Aerospatiale, British Aerospace, and Lockheed , possessing transport aircraft manufacturing experience, were working on the FIMA-Future International Military Airlifter. In December 1987, Aeritalia and CASA-Construcciones Aeronautics S.A.,Spain Based aircraft manufacturer- joined the group. The United States (U.S.) launched the C-17 program to refurbish its long range, high capacity air transport fleet that is in a different category. The capacity of C-17 then became the standard criteria in addressing air transport capability within NATO. The U.S. also depended on the C-130J to renovate its aging C-130 fleet as well as modify the present aircraft. For two reasons, to react to this need, European countries decided to follow a different way other than the traditional approach, which is basically acquiring the available system, by doing co-production and licensing arrangements to satisfy national economic and technological goals and to sustain European industrial capabilities in that area. The C-17 resulted in being an expensive solution. It costs approximately $250 million per aircraft. Within a consortium, several European countries started to develop their own transport aircraft and chose the Airbus consortium as the prime contractor. In the Western European Union (WEU) Assembly Document 1484, 6 November 1995, Military Airlift Prospects for the Europe Report (www.fas.org/man/dod-101/sys/ac/row/1484e.htm), this approach is stated as follows:

> (ii) Stressing the need for European countries to have adequate means, particularly airborne for armed forces projection in the context of military or humanitarian operations;

> (iii) Considering Europe's need to manage its military airlift resources in common and to co-ordinate its operational requirements by exploiting its economic and industrial capabilities to the full;
>
> (vi) Stressing nevertheless the need to strengthen and develop this potential (European potential in existing aircraft industry) in order to ensure a high level of equipment for European armed forces and to maintain European industrial capabilities in the face of competition from the United States and Russian military airlift;
>
> (vii) Considering that much is at stake with the FLA programme, not merely for the future of European defense capabilities but for the very survival of the European aeronautics industry;
>
> (X) Noting nevertheless that any delay in this programme makes it necessary to find short and medium term solutions for replacing large capacity military airlift fleets achieved at present through the procurement of American or Russian aircraft with economic consequences European industry and political consequences for developing an independent European defence.

On the Airbus website (www.airbus-military.com/requirement_main.html) Europe's need for a large transport aircraft is stated as follows:

> Since 1998 there have been over 60 requests for assistance to deal with international crisis situations, with over 40% requiring the use of fixed wing transport aircraft. More recently, events in Kosovo, East Timor and Mozambique have highlighted the need for a reliable, long reach airlift capability, with maximum interoperability between air forces.

In the same document, the need statement is published under the European Staff Requirement (ESR) section as follows:

> The Air Forces of Belgium, France, Germany, Italy, Portugal, Spain, Turkey and United Kingdom have precisely defined their existing and future military air transport requirements by jointly endorsing the Future Large Aircraft ESR. This represents a remarkable example of pan-European collaboration and an opportunity to standardize transport fleets across Europe.

In this statement, several expected goals of international co-development efforts are revealed. The first is defining requirements jointly, which facilitates an international development effort. This issue was not unknown to the countries that are members of the same organizations such as NATO, the Warsaw Pact or the European Union. These

organizations have policies directing the members to a standardization effort. However, the initial approaches were mostly efforts to integrate existing systems to the framework of the organization within the interoperability concept. Since the defense sector is a technology intense, high money generating industry, the economic goals of individual countries were more powerful than overall cooperation. Besides, technological achievements should have been guarded as national secrets even between the nations belonging to the same organization. However, the current situation is now forcing nations to collaborate because the development of new systems is very expensive and decreases in the budget force the militaries to focus on maintenance costs, which are also tremendous. As the Secretary of the U.S. Navy, Mr. England, stated in his speech at NPS (Naval Postgraduate School), "The tail is bigger than the teeth, and still getting bigger."

Regarding this specific project, Europe was also seeking an indigenous capability independent of the defense industry of the United States. The second goal is generating a source that is expected to be politically more reliable. Starting with the end of WWII, European countries were dependent on the vast resources of the United States to counter the Iron Curtain war machine. However, efforts have always existed to build up national defense industries. The efforts can also be explained by basic economic considerations. The defense industry generates jobs for citizens as well as a large amount of cash from foreign sales.

Standardization of the transport fleets across Europe points at the third goal, which is one way to achieve interoperability. Owning the same aircraft would not only supply interoperability within these NATO countries, but also economies of scale. The arrangement made was such that each participant country would build a part of the aircraft that also would ensure the development and survival of the independent European defense industry. This was stressed many times in the WEU assembly document. This fact and concern, in other words, was stated as follows in the introduction section of the same document as well as the possible affordable approaches to the problem:

> 2. Antonov, C-17, FLA-ATF, Galaxy, Hercules and Transall have become familiar names and acronyms for the general public. But apart from their publicity value, they represent substantial political, military, economic and technological investments with far reaching implications... Falling defense

> budgets, proliferation of low-intensity conflicts and the increased role of humanitarian operations require sound choices to be made as resources are limited in a constantly changing world…
>
> 4. This also explains why there is increasing recourse to international co-operation and the strengthening of other options such as the use of commercial aircraft for military airlift purposes. The combination of these two factors enables cost to be lowered while ensuring high levels of technological performance and a wider range of aircraft available…what backing is available for very long-haul flights, and what supporting infrastructure is available on arrival.

In this statement, the trend to use as many commercial items and services as possible in defense systems for efficiency and affordability is expressed as well as the systems support requirements regarding life cycle costs and the maintainability of the related system. Since almost in every European country a national airline is owned in various percentages by the government, using the option of commercial aircraft may be attractive but a commercial aircraft will not necessarily be able to fulfill the military requirements. We may infer that the availability of compatible support infrastructure in more than one country is as important as having a system that can operate effectively with no or limited host nation support.

After addressing the needs statements and general acquisition policy, steps will now be discussed to achieve the goal.

In 1995, the management of the FLA program was transferred to a European consortium through the creation of the Airbus Military Company (AMC). The expected cost of the aircraft is around $80 million. In the same year, the Western European Union (WEU) Assembly Document 1484, of 06 November 1995, concerning the Military Airlift prospects for the Europe Report, was written. It stated that participating countries were to acquire 300 aircraft. Furthermore, in the same document, it was stated that other European countries were to be perceived as potential customers. The maiden flight was scheduled for 2002 and first deliveries for 2004. The aircraft would be designed to be a multi purpose aircraft that could also be used in missions such as electronic warfare and offensive air support. Different versions of the aircraft would be created for use in such missions. Combining design flexibility with the fact that U.S. companies have made no

effort to create a new aircraft in this category, the consortium can also take into consideration that the A400 may be the choice of third countries in the future.

On 4 September 1997, the seven collaborating nations issued a request for a proposal for the Future Large Aircraft to AMC. Each nation specified its potential requirement in terms of in-service date, number of aircraft, support needs and other variables. A competitive RFP was subsequently issued to AMC, Boeing and Lockheed Martin on July 1998 seeking tenders at the prime contractor level. In January 1999, proposals were received from AMC for the A400M, Lockheed Martin for the C-130J and Boeing for the C-17. The final selection basically was gradually made in the year 2000 by the participant nations.

As mentioned previously, the countries will share production. The Airbus consortium consists of companies that are the national leaders in the participant countries. They are CASA (Spain), Aerospatiale (France), Airbus (a French simplified joint stock company with two share holders, European Aeronautic Defense and the Space Company (EADS) and BAE-British Aerospace and Marconi Electronics Systems), British Aerospace (England), DASA (DaimlerChrysler Aerospace A.G.,Germany), Flabel (Belgium) and TAI (Turkey). In 1999, the M138 engine won the down select; and is also jointly developed and manufactured by Snecma (France), MTU Munchen (Motoren-und Turbinen-Union,Germany), FiatAvio (Italy) and ITP (Industria de Turbo Propulsores S.A.,Spain). This is an effort to satisfy the participant's economic goals as well as using the available potential in an affordable manner while also sustaining industrial capability. Attention should be paid to the fact that the Airbus Military Company is highly influenced by governments. On the other hand, for affordability, the work share is distributed according to the capabilities of those national leaders. In other words, the program does not have an objective that requires the transfer of technology to participant countries which, therefore, makes this project different from co-productions usually under offset arrangements. The work share ratios were determined according to the number of planes each participant country will be acquiring. According to the Anadolu Agency (www.turkishpress.com/turkishpress/news.asp?ID=5242, updated 2/26/2002),

the number of planes to be delivered to the participant countries and their work share are as follows (as of November 2001):

Country	Number of planes	Work share of Industries	Work share #plane
Germany	73	37.06	37.24
France	50	24.74	25.51
Spain	27	12.49	13.78
Britain	25	11.84	12.76
Turkey	10	6.70	5.10
Belgium	7	5.19	4.08
Portugal	3	1.99	--
Luxembourg	1	5.19	1.53

As can be seen, the number of planes decreased to 196 from the projected 300 and Italy has withdrawn from the program. This is an example of one of the biggest threats to international programs. A domino effect is very much feared when participants withdraw from the program and then the program becomes seriously threatened by a loss of the feasible number of systems being produced. In this case, the feasible number was 180 A400Ms. However, the first flight was scheduled for 2006 and the first delivery for 2008. This issue somehow leads us to another difficulty in international co-development arrangements: timeliness. Since every participant country expects to gain by being involved in such a program, some participants may drag their feet when they perceive subsidiary goals were not achieved. Timeliness may also be harmed by several other reasons such as budgetary issues, the different law structures of the participant countries, the economic situation of the country, currency and inflation effects or simply one participant's need for the system may not be as urgent/critical as some others for

spending funds on it during a certain time frame. The timeliness issue is also a reason why participants may withdraw from the program. One of the reasons for Italy's withdrawal from the program and acquisition of the C-130J aircraft may be related to this factor.

B. EUROFIGHTER (EF-2000 TYPHOON)

At the end of 1980s, many countries were looking at their options for their next fighter. Their choices were either to keep operating current aircraft, such as the F-16s or F-18 waiting for a more suitable time to acquire a new aircraft incorporating the latest available technology such as stealth or buy a new one in that period. Even though life extension programs were keeping the present aircraft flying, changing mission requirements and emerging new technologies indicated that it was impossible to ignore the introduction of new aircraft to the services. The options were then, either to build the aircraft on their own or buy it from a traditional supplier, which in many cases was the United States. In that time period, different nations, with the ability to design and build an aircraft, were working on different designs. Israel had the "Lavi" which ran into budgetary problems in 1987 and was cancelled. India's "Light Combat Aircraft" also had funding problems. The former Yugoslavia's "Novi Avion" project had been thrown into doubt by the economic situation. Sweden's "Saab JAS39 Gripen" was successfully completed but there was no potential market like France's "Rafale" and the United State's' "Joint Strike Fighter-JSF" which is an example of a success thus far. All these examples may lead to the conclusion stated in "Equipping France's European Fighter", published in Interavia's 12/89 issue:

> In a fighter program that is controlled nationally, the decision process is shorter as there are fewer options and an across-the-board design and production capability is assured for a few more years. As everyone knows, the major disadvantage is that France must bear the heavy cost of a national fighter alone.

One of the other major challenges besides the R&D and manufacturing costs is the difficulty in finding a market for the nationally developed aircraft, especially in situations where the producer does not want to reveal core technologies to the buyers either within the capabilities of the aircraft or by arrangements as such as off-sets and co-

productions. Also, all R&D expenses incurred up to that time would be reflected in the unit price of the aircraft, which makes it unfeasible for many potential buyers. For these reasons, on 16 December 1983, France, then West Germany, Britain, Italy and Spain signed an agreement concerning the Future European Combat Aircraft (FEFA). A joint requirement was issued on April 1984. The design had been expected to be a twin engine but small (therefore inexpensive) aircraft, basically intended to be an air-to-air fighter with some ground attack capability. The partner countries were expected to order 800 aircraft. A search for alternatives and an effort to create combined requirements occurred until 1994 with changes in the participant countries. On January 1994, with the European Staff Requirement (ESR-D), the Chiefs of Air Staff of Germany, Italy, Spain and the UK agreed and signed the operational requirements for the Eurofighter aircraft. In the official Eurofighter website (www.eurofighter.com), this process is stated as follows:

> ESR-D specified an extremely agile single seat, twin engined, delta canard fighter with optimal performance in both supersonic and sub-sonic regions of Beyond-Visual-Range (BVR) and Close-In-Combat, while at the same time retaining a very significant Air-to-ground capability. Maximum operational effectiveness and flexibility, high survivability, extensive technological growth potential as well as high reliability and maintainability at low operating costs were defined as the major design criteria.

In this statement, several assurances about the aircraft can be gleaned. The statement asserts that this aircraft is economic but without sacrificing performance and the aircraft is still a twin engined which usually drives the cost higher. However, a comparison should be made about performance to cost versus performance to cost trade offs of similar aircraft. Besides, the aircraft is pronounced as being suitable for different operations such as air to air, which is the main purpose of the design, and air to ground. This optimizes the solution of one aircraft for a variety of missions.

With the flight test program well underway, the four nations signed a further contract in early 1996 in preparation for the production phase. This included a re-orientation of the requirements of the air forces of the four countries. This also changed the work share percentages agreed upon at the beginning of the program. This contract ensured the commitments of the participants once again. Since the number of aircraft they

required was changing, the participants had been asked to commit their final requirement numbers. The final aircraft requirement figures agreed on in January 1996 are: 232 aircraft, UK-37% work share; 180 aircraft, Germany-30% work share; 121 aircraft Italy-19% work share; 87 aircraft Spain-14% work share. In January 1998, NETMA (NATO Eurofighter and Tornado Management Agency), which is the main customer for the Eurofighter Weapon System and the Eurofighter GmbH, subsequently signed production and support contracts for the initial purchase of 620 aircraft. On 18 September 1998 the Supplement 2 agreements to the production contract were signed in Munich, which was a fixed-price contract covering the production of the first 148 aircraft.

In February 1999, the Eurofighter received the request for a proposal from Norway, the first nation outside the four partners for 20 aircraft in addition to 10 optional aircraft followed by Greece in March 1999 for 60 firm and 30 optional aircraft.

Several industrial consortiums were set up as part of the project. The Eurofighter GmbH was created to manage the development of the complete weapon system. It is owned by these four partner companies with agreed upon development work shares of:

- BAE Systems (BAE-UK)-33%
- Alenia Aerospazia (Italy)-21%
- EADS (former DASA, Germany and CASA, Spain)-46%

Eurojet Turbo GmbH was created by Fiat Aviazioane (Italy), ITP (Spain), MTU-Munchen (Germany), and Rolls-Royce (UK), to develop the EJ2000 engine.

Another consortium established for this project is the Euroradar, which is a consortium brought together to develop the all-new Captor radar. It is headed by BAE Systems (UK), and includes FIAR (Fabbrica Italiana Apparechiature Radioelecttriche, Italy), EADS Defence Electronics, and ENOSA (Empresa Nacional de Optica S.A., Spain). This is the reaction of the industry to the goals of involved nations and also to introduce the benefits of co development/co production to the program.

As is obvious from these figures, the work share arrangement took into account the economic goals of the participant countries with government intervention highly visible. Further proof of this statement is provided as the inclusion of Greece in the

project is examined. The Hellenic Air Force launched a program for the procurement of 60 new aircraft with an option for a further 30 aircraft. Following a competition that included the F-15, Su-27, the Mirage 2000-5 and the Rafale, the Eurofighter was selected to meet this requirement at a meeting of the Defense and Foreign Affairs Committee on March 2000. The Eurofighter has offered Greece a full partnership in the program combined with a substantial industrial participation program. As part of the contract arrangement and inter-Government agreements, Greece will become a full partner in the NATO Eurofighter Management Organization. The Eurofighter will continue to maintain strong contact with Greece in an effort to determine options for a reasonable solution to future budget issues and alternative payment plans within existing constraints. Offering the Greek Industry future work as well as the ability to have a say in future variations to the aircraft design created the market. When taking consideration that this program, with around 150 first and second line suppliers, a total of 400 companies and 150,000 people involved over the next 20 years in the development and production of the aircraft, this offer seems to be a significant incentive.

Another interesting procedure regarding the goals of participant nations was that the test flights of the seven prototypes, named starting from DA1 (Development Aircraft number one) to DA7 (Development Aircraft number seven), were also shared among the participants. In 1994, the first prototype, the DA1, flew from Munich (Germany). The second, the DA2, in the same year, flew from Warton (England). In 1995, the DA3 flew from Caselle (Italy). In 1996, the DA6 twin seat, flew from Getafe (Spain). In 1997, the DA7 from Caselle (Italy), the DA5 from Manching (Germany) and the DA4 from Warton (England) were flown to test components and tactics such as radar, hardened shelter compatibility, air-to-air refueling, modified nose, and lightning strike trials. By September 2000, the seven development aircraft had logged a total of more than 1,300 flying hours and well over 1,400 test sorties. There were many examples of this procedure before and especially within NATO. The problem was, nearly all the participants requested the establishment of such an expensive facility in their country since every country envisions many future benefits in having a test facility. Some of the benefits foreseen by having such a facility are access to technology, training of national

scientists/engineers, generation of high paying jobs to the most educated work force, and possibility of future R&D jobs, all at the expense of the partnership.

The Eurofighter is now in full production and will enter into service in 2002. The four partner nations have ordered 620 aircraft while Greece has committed to 60 with an option for a further 30 aircraft. Norway did not make any commitments.

Eurofighter International (EFI) based in London, is the dedicated export sales and marketing arm for the Eurofighter Typhoon program and is responsible for export sales. The industrial partner scheme applied to Greece is open to all export customers. Through NETMA (NATO Eurofighter and Tornado Management Agency), which was responsible for only Tornados prior to the Typhoon, the partnership is able to utilize the experience gained thus far. However, as is obvious, finding markets for any expensive major weapon system is a bigger challenge in today's environment.

C. MEDIUM EXTENDED AIR DEFENSE SYSTEM (MEADS)

During the Cold War, the two powers were balancing their ballistic missiles capabilities by maintaining a similar numbers of missiles. However, the technology spread to countries other than the two powers and especially right after the collapse of the USSR. Much of the work force experienced in nuclear, biological and chemical weapons production as well as ballistic missile technology looked for countries, that would welcome their knowledge; it was obvious that the former Soviet Union would no longer be able to support their programs. Many ended up in non-developed or developing countries. These countries, not possessing large, armed forces spread worldwide and with little global influence, had an incentive to own and maintain ballistic missiles to achieve their political goals or just to present a considerable threat when religious differences were an issue. Mass destruction capability would also deter some of the organizations such as NATO and United Nations from interfering in conflicts for humanitarian and similar reasons since these organizations would not tolerate casualties. This threat dictated that troops on the field as well as cities and potential strategic/tactical targets should be defended. Two types of changing threats were addressed in "Perestroika Factor in Western Air Defense Systems" by Brian Wanstall (Interavia, Issue 3/1989):

> …the traditional one of large numbers of high-speed combat aircraft supported by jamming devices and terrain-fallowing high-subsonic and supersonic cruise missiles accompanied by diving tactical and anti-radar missiles. These will be accurate enough to hit NATO SAM sites, airfields and other key targets in forward and rear areas, plus the port facilities so vital to the NATO reinforcement plan.

An eight nation project group of the Independent European Planning Group (IEPG), consisting of members of NATO, has been studying future medium-range surface-to-air missile (MSAM) requirements and developing European Staff Target outline. In August 1988, the eight countries (France, Germany, Italy, the Netherlands, Norway, Spain, the UK and Belgium) signed a Memorandum of Understanding for a joint one-year MSAM study in association with industry. However, at the same time, many of these countries were working on and funding their own solutions. Former West Germany was partly funding the development of an Advanced Tactical PATRIOT under the terms of a U.S.-German Memorandum Of Understanding on air defense along with its own national MSAM project, the Taktisches Luft-Verteidigungs-System (TLVS). France and Italy were working together for the development of SAAM, a ship borne Surface to Air Anti-Missile system, which they were proposing as a joint feasibility study with the UK and Spain. France had already been committed to the land version of the system that would use the ASTER missile system for anti-missile capability. At the same time, Spain and the UK were proposing the LAMS-Local Area Anti-missile System. In 1989, the UK also announced their own anti-tactical ballistic missile system, the WOLVERINE. The U.S. was working on a PAC-3 upgrade of the PATRIOT system as well as considering a life extension program for the HAWK system that would extend into 2010.

On the Safe Foundation's website (www.safefoundation.org/tech/local.asp) threats and requirements are addressed as follows:

> Increasing existing threats of tactical ballistic missiles (TBMs) and cruise missiles against ground forces deployed in combat theater affect US and allied forces alike. MEADS role in the ballistic missile defense architecture will be to bridge the gap between man portable systems like the Stinger and the higher level missile defenses like PATRIOT Advanced Capability-3 (PAC-3) or the Theater High Altitude Area Defense (THAAD) system.

Also, in the Facts Sheet (BMDO Fact Sheet 210-00-11), the U.S. DoD published, on November 2000, the requirements and the solutions, which are defined as follows:

> In the coming decades, NATO is likely to become increasingly engaged in maintaining and restoring regional peace, often in an international coalition. To undertake this mission with the greatest chance of success, NATO forces must be able to rapidly deploy to regional crises, work with allied forces, conduct fast moving ground combat, and protect themselves from air and missile attack.
>
> The Ballistic Missile Defense Organization's (BDMO) Medium Extended Air Defense System (MEADS) program, previously referred to as Corps Surface to Air Missile , is specifically designed to satisfy the requirement for limited area defense and the protection of maneuver forces against the increasing threat of tactical ballistic missiles and air-breathing targets, including cruise missiles.

The description of the system follows. MEADS will be a highly mobile (mounted on wheeled vehicles) with a low to medium altitude air defense system designed to ensure protection of maneuver forces. The system will use a multi-canister vertical launcher. Advanced radars will provide 360 degree coverage and missiles will be hit-to-kill and used against missiles as well as air breathing targets. MEADS will use a distributed/netted architecture that will allow a MEADS unit to be task organized and configured to address a variety of threats and tactics. A key element of the system will be transportability on C-130 aircraft. MEADS will replace the HAWK and some portion of the PATRIOT system. According to a document published on Director Operational Test & Evaluation's website (www.dote.osd.mil/reports/FY00/other/oomeads.html), the system will contribute to three of the four Joint Vision 2020 operational concepts of precision engagement, full-dimensional protection and dominant maneuver forces.

The MEADS's U.S. origin dates back to the Corps SAM (Surface to Air Missile System) project of the late 1980's and early 1990's. Corps SAM, a joint Army and Marine Corps program, was intended to replace the rapidly aging HAWK air defense system (in service since the early 1960's). The Army and Marine Corps started Corps SAM in recognition of their common need to find a new rapidly deployable air defense system against air and theater short to medium range missiles.

In the early 1990s, Germany expressed an interest in joining the Corps SAM program and cooperating on system development and production. Like the U.S., the German interest stemmed from a need to replace aging HAWK systems. Soon afterwards, France and then Italy, came forward to express their interest in joining. In February 1995, a joint Statement of Intent (SOI) was signed between the four nations. At this point, Corps SAM became officially known as MEADS. The SOI would form the basis of a Memorandum of Understanding (MOU) defining the details of the cooperation for each phase of the three phases. The phases were Project Development and Validation (PD-V), which was to produce a system specification, a primary end item specification and a cooperative program plan for common development and production, Design and Development (D&D), the phase in which actual design work and tests was to be conducted, and Production, in which actual manufacturing work was to be done. The SOI called for a program cost and work share of approximately 50% for the U.S., 20% each for France and Germany, and 10% for Italy. The SOI also laid out the method to manage the procurement process. A multilateral Steering Committee would supervise the soon to be established NATO MEADS Management Agency that would provide program oversight. France dropped out of the project before the signing of the MOU. According to the tailored agreement, for the first phase, the position General Manager would rotate between the remaining two European participants. Germany was to provide the first General Manager. The U.S. would provide the Deputy General Manager. Additional NATO countries were allowed to join the MEADS effort if all participating countries approved. The SOI also detailed the process that would be used to choose a contracting team to build the system. The process paired two U.S. teams, one led by Hughes and Raytheon and the other by Lockheed Martin, with two European teams, each comprised of Daimler-Benz, Siemens, and Alenia. An MOU would be negotiated for each of the three phases.

The first MOU was signed in May 1996 to commence the Project Definition-Validation (PD-V) phase, the first of three phases planned to field the system. The U.S. and its remaining European partners, Germany and Italy, agreed to split work shares and development costs by a ratio of 60% for US, 25% for Germany and 15% for Italy,

although each party had only made commitments to the PD-V phase as stated in the SOI. In June 1996, the Management Organization charter was established under NATO.

Before transitioning from the PD-V to the D&D phase, on 19 May 1999, the Ballistic Missile Defense Organization, basically a predecessor of Independent European Planning Group and the NATO MEADS Organization, announced the selection of MEADS International as the prime contractor, a joint venture comprised of Lockheed Martin of the U.S., DaimlerChrysler Aerospace AG of Germany and Alenia Marconi Systems of Italy. Also, a three year Risk Reduction Phase before entering a full D&D phase was planned.

In this project, the tendency had always been towards a cooperative effort even though many of the countries had their own solutions. This was because the system had to be highly compatibility with the allied nations' systems, and high cost of the system, no national solution was acceptable to the others. As stated in the Congressional Testimony of Brigadier General Emery, USAF, Deputy for Theater and Air Missile Defense Ballistic Missile Defense Organization to the House National Security Committee, Subcommittee on Research & Development and Procurement on 19 March 1997 (http://www.acq.osd.mil/bmdo/bmdolink/html/emery.html):

> …In addition, US forces will likely be fighting alongside coalition partners. Therefore, we must be prepared to fight not just jointly, but with combined forces as well. In some cases, the first TMD (Tactical Missile Defense) systems in a theater of operations may be those of allies and friends. Hence, TMD systems require strong levels of interoperability between US, allied and friendly systems…New development programs are expensive and unilateral development and fielding sometimes makes them unaffordable. Through international cooperative development programs, such as MEADS, true burden sharing allows us to field highly effective defensive systems with our allies in a more affordable manner.

Affordability and interoperability are the main areas of focus. However, affordability did not completely justify accepting a system that was nationally developed by one of the partners. The solution found to ensure commitment to the project was again a work share agreement. In burden sharing arrangements, participants used another very

common method, that of sharing depending on the number of systems to be procured. Also, heavy government intervention, as in many other projects, was present.

Although, PATRIOT PAC-3 was finally selected as the core of the MEADS project, this was not without controversy. Bernd W. Kubbig, from the Free University of Berlin, Peace Research Institute, Frankfurt, voiced some of the concerns in his remarks prepared for the Forum Ballistic Missile Defense, Berlin, 18 September 2000 under the name "The Problematic Trilateral Project MEADS". He claimed that from the beginning the project had been disliked by the majority of the U.S. Congress and not supported by the Pentagon and the military because funding for MEADS from the U.S. had been little and unstable. Funding concerns were also addressed in the Brigadier General Emery's congressional testimony on the strength of the international coalition in developing such a system within the needs to respond to financial constraints on the defense budget. Furthermore, Mr. B. W. Kubbig points to his source, a MEADS report by the U.S. General Accounting Office (GAO), June 1988. He also continues to claim that the PATRIOT PAC-3, being the focus of the system, meant adhering to the "Buy American Act", as stated by a representative of the German Ministry of Defense:

> The U.S., in our meetings has become quite explicit that PAC-3 is the solution and we can agree to co-development only if we accept PAC-3 as the core.

Mr. Kubbig continues with the issue of the transfer of technological data. According to the GAO Report, a release approval of the data had taken as long as 259 days, which urged the participants to demand that the following conditions be met by the U.S. before the next phase of cooperation could start. MEADS had to be a NATO program, how the transfer of information was to be handled had to be clearly outlined, data on the interceptor (PAC-3) had to be made accessible to the greatest extent possible, and MEADS had to be developed in such a way as to yield a fully-operational system. Following these concerns, the U.S. developed a plan to share missile defense technology with the two European partners.

As seen from these statements, sharing information is one of the greatest issues when a participant country sees the information it possesses as a national security issue as

well as, most probably, a core competency within the defense market. Another concern was that if the U.S. chose to integrate the system with its National Missile Defense project, all the components of the system would be U.S. technology which would harm the economic goal of European participants. Such systems being compatible with international agreements, such as the "Demarcation Agreement" signed between Russia and the U.S., would also be a concern.

Last, but not least, such international structures might prevent contractors from pursuing the most cost-effective systems. Sub-contracting, in many cases, will be limited within the participant countries and the approval cycle of more cost effective sources outside the partnership will take longer. In some cases, it would take so long that the entire program would be placed in jeopardy.

D JOINT STRIKE FIGHTER (JSF)

During the same timeframe, while the European Nations were attempting to define their next fighter aircraft, the U.S. was also working on an affordable joint solution. The U.S. had to replace an aging aircraft in the inventories of the Air Force, Navy and the Marine Corps. The Air Force needed to replace F-16s, and therefore, needed an agile, fighter bomber small enough to be affordable, but designed to use the latest available technology such as stealth. The Navy needed an aircraft which complements the F-18s, and wanted to have access to stealth technology especially after the unsuccessful attempt in the A-12 case. The Marine Corps, like the UK Navy, was looking for a replacement for the A-8, a short takeoff vertical landing aircraft. Since the concept is different from the Eurofighter, the JSF existed for a different market. The Eurofighter is basically an advanced interceptor with two engines for high maneuverability, which in bombing missions, because of G/drag limits, would not be a priority.

In a market analysis published in the Defense-i.com (www.defense-i.com), the JSF is described as follows:

> The Joint Strike Fighter (JSF) will be multi-role fighter, capable of carrying out ground strike-missions, interception and patrol, while making use of the latest advances in stealth technology, weapon systems and computer communication.

As stated, the JSF will be a single engine stealth fighter-bomber. It will have the capability of carrying external loads (losing stealth capability) as well as internal weapon bays. Three types will be manufactured: the conventional type (CTOL) for the Air Forces, the short take-off/vertical landing (STOVL) types for the Marine Corps and the UK services, and the carrier model (CV). It will have an Advanced Electronically Scanned Array (AESA) radar which will support air-to-air, air-to-surface and electronic warfare operations. A common engine, the Pratt & Whitney F135 (JSF version of F119), was chosen as the propulsion system.

The program started as The Joint Advanced Strike Technology (JAST) program. The U.S. Secretary of Defense's Bottom-up Review in 1993 acknowledged the need to affordably replace aging strike assets in order to maintain the military's technological edge, and consequently established the JAST program. The program is jointly manned and funded. Legislation merged the Advanced Research Projects Agency (ARPA) and Advanced Short Take Off/Vertical Landing (ASTOVL) program with JAST. JAST inherited much of the defunct A/F-X project as well as combining with the ARPA's X-32 project and thus received the name JSF.

The X-32 started as ARPA's ASTOVL project, and was intended as a technology demonstrator leading to a supersonic successor to the Harrier (A-8). The latter became the Common Advanced Lightweight Fighter (CALF). It was a more general demonstrator for a future lightweight fighter. The UK was also involved in the project and contributed about one third of the money. This relationship ensured the UK's current position of full-collaborative partner status offered only to the UK by a MOU signed on 20 December 1995. The UK participated $200 million to the Concept Demonstration Phase.

The JSF program completed its Concept Exploration Phase in December 1994. The results of that phase underscored the possibility and benefit of commonality as a viable means of achieving significant savings in next-generation aircraft. The key conclusion was that a family of aircraft could meet tri-service needs with an significant overall Life Cycle Cost savings. The main emphasis of this project was affordability. In fact, by using cost as an independent variable and addressing a common solution, in the

main frame and mainly sub component level, the project attempted to shorten the tail. Mr. England, Secretary of the Navy (2002) addressed in his speech given at NPS.

The U.S. JAST program was intended to be a technology-development program rather than an actual service aircraft. It involved all the improvements that would be expected from a next generation aircraft such as advanced materials, stealth, reduced costs, and better systems integration, in addition to two particularly innovative concept:

The first is modular aircraft design so that individual aircraft could be built with different combinations of components for different services and missions, such as take-off capability. The same basic airframe could be built in conventional runway versions for the Air Force, carrier-borne versions for the Navies, and the V/STOL version for the Marine Corps and Navies.

The second is providing a virtual reality environment for the pilot which would integrate network-provided tactical information with the outside view.

Twelve technology development contracts were awarded in May 1994 with the largest going to Boeing. Two contractor teams out of Lockheed, McDonnell Douglas/Northrop and Boeing would each build two demonstrators.

In May 1996, the JSF was designated an Acquisition Category I, DoD acquisition program. In June, the weapon system prime contractors submitted their Concept Demonstration Phase (CDP) proposals. A formal Milestone I Acquisition Decision Memorandum was signed by the Under Secretary of Defense (Acquisition & Technology) on 15 November 1996, clearing the way for the award of CDP prime contracts to Boeing and Lockheed Martin on 16 November 1996. The Pentagon gave Boeing and Lockheed Martin $1.4 billion each to take their best shots at designing the fighter.

Two prototypes would be built, representing both conventional, carrier capable and STOVL versions with the first operational fighter planned to roll out in 2008. Around 3,000 aircraft were foreseen to be demanded by the U.S.,U.K. and potential third country customers. The program would consist of three phases: Concept Demonstration Phase (CDP), Engineering and Manufacturing Development Phase (E&MD), and Full

Production Phase. Distribution of the aircraft to the participating countries would be made on an equal basis. In other words, every participating country would receive a portion of their order basically at the same time. Participation in each of the phases would be optional and required a certain fee be paid according to the level of participation. Furthermore, participant countries would obtain a percentage of the sales to third countries that was determined according to their level of participation. Industry participation would be on a sub-contractor to the chosen prime basis and the country industry share would be based on competition, unlike most other international projects.

Finally, on October 26, 2001, the Defense Department selected Lockheed Martin's F-35 as the winner of the competition to manufacture the Joint Strike Fighter. The UK and, on 7 February 2002, Canada, announced their participation in this phase. According to the Military Library Database (Dudley Knox Library web page, www.nps.navy.mil-02/07/2002), Canada's commitment for the next ten years will be $150 million. Also, the Netherlands, Italy, Norway, Denmark and Turkey expressed interest in participating in that phase.

International involvement in the program was also a method to create an affordable aircraft when considering efficiency and burden sharing and as a secondary benefit of doing the market research from the beginning when the level of participation and willingness of the countries is taken into account. The JSF program would incorporate as many international participants as practical. The Program Office created a framework for international cooperation that had four levels.

- Collaborative Development Partner: A full partner greatly influencing design and having access to all efforts
- Associate Partners: Limited partners with limited participation in specific technologies or core programs
- Informed Customers: Allowed information on JSF processes to permit them to evaluate the utility of the JSF family of aircraft for their use but were unable to influence requirements
- Foreign Industry: would be able to participate under a 'Fee-for-Service' category by subcontracting to U.S. primes for subsequent phases of the program. Russian, British and French firms participated at this level.

The participant countries and their status of participation are discussed as follows:

- A multi-lateral MOA with Denmark, Norway, and the Netherlands was successfully negotiated in October 1996
- A MOA was signed by the U.S., Norway, and the Netherlands in June 1997
- A MOA was signed by Denmark in September 1997

Countries have entered the program as Associate Partners:

- Negotiations with Canada were completed in May 1997. A MOU was signed in December 1997. Canadians entered the program as Informed Partners in January 1998.
- Italy signed a MOA on 23 December 1998 for participation in the JSF Program as an Informed Partner. Italian cooperation covers several carrier suitability and environmental projects for JSF during the current phase of the program.
- Singapore signed a Letter of Acceptance (LOA) on 20 March 1999 to become a Major Participant
- Turkey became a Major Participant on 16 June 1999
- Israel signed its Letter of Offer and Acceptance on 23 September 1999 to become a major participant

Except for the UK, all the participants participated as 3rd levels.

On the JSF official website, the advantages for international participants are declared as follows:

- Access to JSF Program information to assist in determining if the JSF meets national requirements for a strike fighter
- Use of modeling and simulation tools to assist in requirement validation effort
- Conduit for foreign industry to engage U.S. industry in the formation of future partnerships
- Bridge to possible participation in future phases of JSF (e.g. Engineering & Manufacturing Development, Production)
- Influence requirements if mutually beneficial to participants

One other reason for the expectation that this international program will be successful is that the acquisition of this particular aircraft from U.S. Services is absolutely dependent on participation in the program. Therefore, participants do not want to lose the potential benefits to be obtained from this program. This is supported by the

idea that the JSF will be the only affordable stealth fighter-bomber for the next 20 to 30 years and these countries will be acquiring this aircraft one way or another.

The program was also regarded as a pilot project to see if the new concepts such as technology maturation, cost as an independent variable, joint weapon systems, modular design and international involvement would work. On the Defense-i's web page, there is an interesting observation about aircraft industry consolidation.

> As a result of mergers and acquisitions over the past ten years, the total number of prime manufacturers of military fixed-wing aircraft has declined. So rapidly has the defense industry shrunk in recent years that 'consolidation' sometimes seemed a polite way of saying 'collapse' as one famous name after the other disappeared into a black hole. But for the aerospace sector, the implosion is almost complete. What has survived is a surprisingly healthy business.
>
> What may be most remarkable about the consolidation of the industry is that the customer (the Pentagon) kept its hands off. Instead of urging particular companies to join with another, which it might have justified as essential for national security, the Pentagon effectively left them to sort it out. They did, and it worked.

Although the statement renders powerful substantiation of this idea, the actions of the U.S. cannot be expected from many other countries. The U.S., being a major weapons exporter, could leave the aircraft industry adjust by itself within market rules since the industry was strong enough to survive after the struggle. Boeing, being a major supplier in world civilian airplane market and recently landing the big transport aircraft contract for the C-17, had enough capital and future work to survive. On the other hand, Lockheed-Martin was a big player in the fighter aircraft arena and their latest contract was the F-22. Although both firms divested many of their divisions in different areas, their situation was strong enough to react to the changes. However, in other nations, the national aircraft industry had no chance of surviving whatsoever without government subsidies. The biggest European firm, Airbus, had been subsidized many times in many forms such as being the first choice of European nations when acquiring transport aircraft.

The JSF was also important as the largest potential aircraft contract for the U.S., UK and other countries in the foreseeable future. Furthermore, the JSF program would be conducted under the DoD's acquisition reform initiatives begun in 1994. These initiatives mandated a new way of doing business, cancelled many government standards and specifications and stated the service's needs in performance-based terms and thus welcoming many new concepts as previously mentioned. In the "JSF Program Whitepaper", the Cost as an Independent Variable (CAIV) concept is mentioned:

> To an unprecedented degree the JSF Program is using cost-performance trades early, as an integral part of the weapon system development process, to enable achievement of an affordable mission effective solution to the Service's needs. The services are defining requirements through an iterative process, balancing weapon system capability against life cycle cost at every stage. Each iteration of requirements is provided to industry. They evolve their designs and provide cost data to the war fighters. The war fighters then evaluate trades and make decisions for the next iteration.

Furthermore, the technology maturation concept, demonstrating that technology is established prior to E&MD in order to reduce cost and risk, has been a key element. In the GAO's Report about Joint Strike Fighter Acquisition (GAO/NSIAD-00-74, May 2000) this issue is addressed as follows:

> Matching the aircraft requirements and the maturity of technology as a program begins is perhaps the most important determinant of a program's success. Once a program begins, a large, fixed investment in the form of human capitol, facilities and materials is sunk into the program and any significant changes will have a large, rippling effect on schedule and cost. In the case of critical technologies, beginning an acquisition program when the technologies are at a low level of development increases program risk and the likelihood of schedule delays, which increases program costs.

Other cost reduction concepts are the family of aircraft concept and having a modular design to adapt an interchangeable assembly plant for affordability and mission effective solutions for each service's needs. Cost reductions result from using a flexible manufacturing approach and common subsystems to gain economies of scale. Emphasis is on commonality in the higher priced parts. This concept is also expected to create huge savings from common depot maintenance, commonly supported logistics as well as

increased service interoperability. Performance based contracting is defining the desired performance rather than telling the contractor how to do it, and thus giving the contractor flexibility as well as allowing cost-capability trade-offs in a wider aspect. From the beginning, development savings from the JSF family of aircraft approach compared to three separate programs for each service are estimated to be nearly 40%.

The U.S. Air Force will be the largest JSF customer and will purchase 1763 CTOL aircraft. The U.S. Marine Corps is expected to purchase 609 STOVL aircraft, and the U.S. Navy about 480 CV aircraft. The U.K. Royal Air Force and Royal Navy will purchase 150 of the STOVL aircraft. The purchases of participating and third countries have not yet cleared.

III. GENERALIZATION OF PROBLEMS AND LESSONS LEARNED FROM THE EXAMPLE PROJECTS

This chapter will define the issues, concerns and solutions implemented that were extracted from the example projects. Many of the issues within the chosen projects were similar since all of the chosen examples are Acquisition Category I, major weapon system projects and in many cases the participant countries are the same. Besides, such projects involve large investments, new technologies and major impacts on both national security and economic dimensions. Governments therefore will actively influence these programs. This chapter will not attempt to explain participant motives in detail; the motives will not only encompass efficiency and economy, but also the political climate at that time. Thus, every project and every participant country could have been investigated in terms of national political and economic history, as well as the history of the organizations such as NATO.

Five issues associated with the example projects will likely be issues in future international co-development programs. These are technology, security, economic, and industry issues plus R&D/burden/production sharing.

A. TECHNOLOGY RELATED ISSUES

All Defense Departments want to provide war fighters with weapon systems that embody the latest available technology. It is a proven fact, seen especially during the Gulf War and the conflicts occurring afterwards, that there is very low tolerance for casualties today. Therefore, it is necessary to provide technologically more complicated systems to the war fighters, but of course at a price. In fact, providing the latest technology to war fighters was the strategy of the U.S. and NATO, while the former USSR and the Warsaw Pact were depended more on mass attack with a lot of armor. The technologically advanced weapons needed were acquired by the participant nations in two ways. The superpowers were able to develop their own but many countries did not have the required level of industry and knowledge to do that; so they purchased weapon systems through Foreign Military Sales channels. In developing their own method, nations were depending on sales to other countries to obtain a break-even level of

production. In many cases, that number would not be reached because nations capable of doing so preferred to develop their own weapon systems. Buyers also wanted to be independent in national security related matters, had national economic and political goals, and also had concerns about technology transfer and industrial capabilities. Buying from another nation raises the concerns and problems previously mentioned. Weapon systems are acquired with a support package. Buyer nations will be seek cheaper ways to acquire that support, hopefully with an approach that would involve and improve their own industry. Offset, technology transfer and co-production type arrangements are some of the solutions implemented to satisfy those concerns. However, these arrangements depend on whether the buyer is a developed, developing or underdeveloped country.

Co-development arrangements are usually done between developed and developing countries as we saw in the chosen examples in this thesis, for several reasons. First, the industry of underdeveloped countries cannot accommodate effective production of large, complex weapon systems. Many firms from these countries do not compete in the weapon systems market even at the sub-contractor level. Their participation will depend on the transfer of many advanced technologies. However, in many cases, these countries do not buy enough systems to justify transferring the technology. Besides, the source country may not be willing to transfer the technology. The technology may end up in another country that is not politically favored by the source. The likelihood of this happening is a greater risk since underdeveloped countries also have economic concerns. In the Eurofighter program, if participant countries are approved up to the approved level, third countries are promised participation in the production, probably with a technology transfer arrangement. However, current participants simply will not approve participation of a technologically unsatisfactory third country. They are only offering production participation because the design is already in place. The FLA program is tailored to satisfy the operational needs of the participant countries as well as addressing solely using the European Aeronautics Industry. Besides, the program addressed interoperability within NATO forces. That may be a concern when a non-NATO nation considers FLA. When looking at the work share arrangements in all these programs, participant nations competed according to their industrial and technical capabilities. Thus, there is no

foreseeable enlargement that includes technology transfer to another country in the near future. Likewise, MEADS was designed in ways that may not fit the requirements of a third country. The program had problems with knowledge transfer among the current participants, and therefore does not present an example of easy access to technology. JSF may be the most suitable program among the examples that can fit the requirements of a non-participant nation. The program does not promise an economic return, but points to potential return in early involvement. This approach is expected to drive costs down, and thereby resulting in a more affordable aircraft.

Developing countries have experience in production and development of complex systems because of earlier exposure to co-production, licensing and/or offset arrangements. Turkey and Greece are some of the countries in this category. It is easier to transfer technology because these countries have most of the technical background as well as skilled personnel needed. Their participation may necessitate some degree of support, but they are more cost efficient in many cases. The program may reduce costs considerably, especially those related to labor as an educated labor's opportunity cost is usually lower than in the developed countries. These countries are economically more stable. Therefore, in the long run, transferred technology and knowledge may be used in other areas, independent of the subject program that frees both sides (source and participants) from obligations to maintain the industrial base. This is also helpful when other co-development arrangements are considered with the same country. Knowing how to cooperate is as important as being willing to cooperate. Countries in this status have expertise in this area. Furthermore, such countries are already cooperating with developed countries because they are usually members of organizations such as NATO.

Co-development arrangements between developed countries are sometimes harder to implement. Arrangements are usually made to share technology that other participants did not have or are not as effective in implementing. Efficiency and savings are achieved by not reinventing the wheel. While one of the participants has the technology for the wheel, the other has the axle and the main purpose is to share this technology in order to build the car. In some cases, countries do not want to share the technology they possess as they feel that they may lose a core competency in the market and therefore lead to a

loss of future jobs. National industry champions will be involved in the project. Their approach to economic goals will necessitate the involvement of politics, thus leading to government intervention. At that point, efficiency may no longer be a high priority. If one party feels another is slow to share knowledge, the entire program could be in jeopardy. Participants may appear to act as if the main purpose of the program is not to field an operable system but to gain access to technology others possess.

The chosen example programs in this thesis are all co-development programs between developed and developing countries. Some of these aforementioned issues can be seen in these projects. In MEADS, Germany accused the U.S. of not releasing enough knowledge on time. FLA was addressing the technological capacity of the European Nations. When Italy decided to leave the program, other nations luckily had the capacity and technology to assume for the Italian work share. With the Eurofighter, every participant nation had its own aircraft design, but they could dedicate their resources to a common solution. This was achieved by recognizing the forte of the other nations. The JSF program is introducing a stealth aircraft to the market. Up to now, only the U.S. used that technology. There is also a very famous example of failure: the U.S. Navy's A-12. The A-12 was supposed to be a stealth carrier based aircraft for the Navy. However, the program did not receive enough support from the U.S. Air Force, which had the expertise and knowledge in this field. The program was abandoned and much money was lost. The reasons for failure were not the same but are good examples of what might have been achieved if knowledge had been transferred to the Navy program. When thinking in terms of international programs, this particular technology would naturally be guarded by the U.S. (the fact that only the U.S. used and was known to use stealth technology may justify this behavior). Besides, the U.S. is the only country that can currently implement the technology efficiently when taking learning curves into consideration.

In general, international co-development may help realize affordable, interoperable, and advanced weapon systems. This is because defense budgets are not large enough for most countries to be experts in every required technology, nor it is probable that they will be efficient in implementing them. Instead of struggling to

improve in every area, cooperating to share talents seems a win-win situation for the participants. It may very well help in fielding the weapon systems discussed earlier.

B. SECURITY ISSUES

In some situations, countries do not want to share information with other countries, even if they are cooperating to some extent. This may occur for several reasons. The source country may feel threatened if a likely competitor obtains access to a key technology. The danger of losing a portion of their market share may lead them to act in such a way. Besides, all defense issues are affected by politics. Nations are cooperating with nations deemed to be politically close to them. Third party access is strictly controlled. Through the end of the Cold War, industrial espionage was regarded as a great danger. Reverse engineering was not uncommon. However, most of that concern today is a result of economic interests. Governments may resort to extreme measures to preserve key technologies. Furthermore, a national defense industry, independent from other countries, although not possible in a global environment, still is a dream of many governments.

Even though the Cold War is over, there are many other threats that can necessitate extensive security measures. One example is terrorism, which knows no boundaries. Others are ethnic conflicts in which neither friend nor foe can be clearly defined, unstable governments owning ballistic missiles, and easily produced chemical and biological weapons. In general, nations behave according to the principle "No eternal enemies, no eternal foes". They are picky in choosing which nations to cooperate with and consider the circumstances that may occur in the future. This future could last as long as 25 to 35 years over the life cycle of a weapon system. Being attached to a country even at a sub-component level today may lead to vulnerability tomorrow. Therefore, co-development partners are usually also seen as strategic allies. In all the example projects chosen, participant nations were related to each other through NATO, Europe, the European Union or some other strategic alliances. FLA involves European nations that are also partners in NATO. The Eurofighter involves European Nations in European Union. MEADS participants are NATO countries already involved in a key part of the PATRIOT system. The U.S. is certainly inviting countries that are politically close to

participate in the JSF project. Besides, it is usual practice to include a clause in the weapon system sales contract making it mandatory to obtain the approval of the source country before selling the system to a third party. Almost all the participation MOU's requires the approval of existing participants when a new country's participation is considered (even if they are customers).

The global environment forces nations to be more flexible in sharing information. Shrinking defense budgets requires nations to seek more efficient ways to satisfy the needs of the war fighters. However, security procedures pose a considerable barrier to seeking that efficiency through international co-development efforts. For example, it is very unlikely that the U.S. and China will be involved in a co-developed weapon system program in the near future. The precise ownership of data is not clear even between the same country's government and industry. As mentioned in the technology issues section, the possibility of technology ending up in a politically unfriendly country and the possibility of reverse engineering push the source countries towards the "black box" approach. Solutions implemented so far were full communication and show of intent. Participants should put the desired rules on the table at the earliest stage to mitigate potential future conflicts, which always delay the program for months or in some cases result in its complete abandonment. This approach may necessitate sacrificing a nationally supported solution as happened with MEADS. Italy, the U.S. and Germany had their own solutions for a common need but no participant was willing to accept the others solution. In the end, participant nations decided on the requirements and design features from scratch.

In some cases, sharing knowledge does not harm the source. As the source country usually offers the most efficient way of implementing that knowledge; and, the competition from other countries may never be significant when the learning curve is considered. Finally, the examples also prove that international partnerships usually occur between the nations belonging to the same organization or already having a strategic partnership arrangement in pursuit of a common interest.

C. ECONOMIC ISSUES

The stability of a program is directly related to its funding. A large weapon system program may both be a huge expense and at the same generate revenue for a nation. This section will discuss the economic issues in two dimensions. First is the availability of a participant's economic resources. Second is the economic expectations and goals that motivate the country's decision to participate in a program.

Several programs proved that the cost and schedule of R&D programs could not be precisely predicted. Many times contingency funding and schedule extensions are needed. It is many times not preferred to stop an R&D effort after the program has received a lot of money. Program managers, especially when their careers depend on program's success, will be motivated to try to make the authorities believe that if a little more funding is released, the program will be a success. However, when there is international involvement, much effort is needed to have more funds released. The budgeting systems in many countries are more or less similar. Almost all the systems practice a period based approach and available resources are allocated in five year, two year or yearly plans. Usually there is very limited flexibility for contingencies. No matter what the status of the country, allocating more funds to a program means taking funds from another program. In developing countries, even that limited flexibility may not exist. In many cases, the Foreign Military Sales (FMS) offices handled the contract based on the guarantee of a developed country's government. This supports the argument that in general only developed and developing countries participate in co-development programs. It may be hard to justify guaranteeing an underdeveloped country's participation through FMS because they may never be able to repay the funds credited to them. Instability may downgrade the economic conditions so much that that participant may be obliged to leave the program and thus endanger the entire group.

Also, there usually is one country in the partnership that pursues the program more aggressively than the others that can be called the "champion country". For example, in FLA and the Eurofighter; Germany, in MEADS; the U.S., in JSF; the U.S. and Britain were the driving forces behind the progress of the program. The number of systems these countries intend to acquire justifies their behavior. Thus, these countries

are motivated to make the program economically attractive to possible participants by offering flexible burden sharing arrangements, compensating more of the cost than the other participants, putting more funds in the program upfront, and offering economic benefits, or by other means. In other cases, the program may present such an opportunity that it may attract the desired level of interest. One reason for other participants' attraction to the program may be the guarantee that the source country will complete the project even without international participation. The JSF is an example of this argument. The goal is to produce an affordable next-generation fighter-bomber. It is estimated that the JSF will dominate the market in its class for the next 25 to 35 years. It is seen as the successor to the long lived F-16. The U.S. and Britain have been working on the concept since 1994. Although the U.S.'s funding seemed to be in jeopardy after the U.S. Air Force declared the F-22 the desired aircraft, the situation was resolved after the JSF program was designated an ACAD-I program in 1996. It can be argued whether or not the program is made more complicated by inviting an international presence. At first, the program seems strong enough to withstand threatening behaviors such as one or more participants leaving the program as occurred in the case of the FLA and Italy leaving the program. Second, since this is an R&D and a production effort, contributions to efficiency at every phase of the program will be welcomed. Economies of scale should also be considered. Every participant in the program is a customer with a demand for more production, and thus cost per aircraft decreases. Early participation also makes future funding more predictable and stabilizes the program as well as making possible to take advantage of opportunities as they appear. Also, the program offers an economic return to the participants. While Eurofighter is using production share and a possible technology transfer as a marketing tool, JSF is offering returns (depending on the participation level in the R&D phase) from sales to non-participant countries.

Looking at this from another angle, champion countries are expected to behave as described above. Germany's accusation of poor funding from the U.S. for the MEADS project may be a result of these expectations. Of course, there were other issues such as timely technology/knowledge transfer, a purely U.S. system (PATRIOT PAC-III) declared to be the core component of the system. Practices such as offsets and co-

production arrangements are expected to be a part of weapon systems contracts, because as Barry Marvel stated in his article published in Contract Management/May 2001, titled "International Offset Practices":

> Offset contracting is a dynamic, constantly evolving process that reflects changes within a country's economy and society.

An incentive program became the usual practice in marketing weapon systems, which leads to a discussion of the second issue: Why countries are willing to join such programs from an economic point of view. One reason is expectation of economic returns to the society. Governments want at least a portion of defense spending to go to domestic businesses. Laws and regulations such as 'Buy National" acts support this desire. In some situations, sub contracting for specific items within the buyer country may be a prerequisite. Such practices serve many purposes. In major defense programs, a developed country's currency, such as the U.S. dollar or Euro, stays within the buyer country, which is important for developing countries. Jobs are created for the society that may not be efficient in economic terms when considering the "broken window fallacy", but positively affects the leader. When subcontracting is mandated, technology, education/training and manufacturing methods are usually transferred. When considering the points made in the previous sections, participants may have the opportunity to gain experience in new areas. Besides, participation in development also means participating in production; when big weapon systems are considered, production may be sustained up to 30 years. The program will also be supporting the related portion of the Defense Industrial Base.

Until now, co-development seemed to benefit countries other than the champions. But, champion countries have many reasons to pursue a program aggressively. First of all, burden of the expensive R&D will be shared. In some situations, international involvement may preserve the program. It is always harder to leave an international program than it is to abandon a national program. Funding may be more stable since participants may choose not to withdraw thinking about their prestige. The countries will be exposed to new technologies, training/education and manufacturing methods. Participants therefore do not have to excel in every significant area. International

arrangements provide enormous opportunities from exposure to the latest technologies, to cheap labor and to innovative manufacturing methods.

It was mentioned previously that national programs usually do not obtain the targeted production levels. This threatens the program. Before potential customers seriously demand the system, it should be tested and proven in a conflict. Co-development programs do not need such testing methods. The commitment of the countries to the program is a sign that they will be purchasing that system. Usually the participants' demands also include sharing burden for the number of systems to be acquired.

Another issue may be determination of the base currency. A base currency for program targets should be determined. Participants may be confused by the use of multiple currencies. Currency becomes a big issue especially when inflation is a concern. Instabilities may affect one participant more than the others. In general, U.S. dollars are chosen as the base currency, and payment arrangements are negotiated according to the needs of the participants.

In general, every participant seeks an economic return when considering a partnership besides satisfying the needs of the Armed Forces. International partnerships offer many opportunities. Although industry clearly understands these opportunities more than the governments, the great responsibilities faced by these governments may justify their careful behavior.

D. INDUSTRY RELATED ISSUES

In an international partnership for developing weapon systems, governments are involved not only through their own Departments of Defense but also politically, having secondary goals in mind. In general, the desirable environment is for companies to team up and compete for the award. In an ideal situation, they will offer efficiency, better performance and cost effectiveness in order to be awarded the program. However, buyers usually put forth national enterprises as part of the winning team because of these secondary goals. At first, politics is fed by industry money. A weapon systems contract will result in a lot of revenue for a period of 20 to 30 years. Industry lobbies are usually proactive about such opportunities. Therefore, the representatives of the participant

nations bring to the negotiations a strong desire to guarantee their national industry's involvement. In our example programs, the usual practice is to agree to a work share arrangement. FLA, the Eurofighter and MEADS programs all used the same technique to satisfy the participants. In JSF, such an agreement has not yet been reached, but participant countries are expecting manufacturing shares to be at the sub-contracting level.

Governments and international treaties strictly control the defense businesses. Governments may interfere with mergers, sales to other countries and/or protect the firms. Traditionally, defense contractors always are supported to a certain extent by governments, since they represent the nation's independence and many nations have had the unfortunate experience of suffering under arms embargos. Another reason defense firms obtain support is that governments are liable to perform many duties with limited resources. Defense is usually a large portion of national budgets. Therefore, governments want to obtain the best value for their purchases. The most effective way to obtain the best value seems to be through competition. The government has the incentive to support contractors to sustain competition. Some of the methods to reach that objective may be regulations to prevent monopolies by not allowing mergers, sharing the production of a weapon system between two contractors, requiring the winning contractor to sub-contract components to the other contractors or encouraging/discouraging teaming between the contractors. In some countries, competition is not possible because only one contractor is capable of performing the work. It is very difficult to obtain these capabilities and sustaining them is even harder. They need more support than their counterparts in developed countries. Governments support them through several methods such as arranging partnerships with contractors outside the country as a prerequisite in buying a weapon system, making advance payments, awarding maintenance contracts and rendering financial help to gain more capabilities. These contractors can be regarded as national favorites which is either advantageous to the prime contractor or disadvantageous depending on the situation. The prime contractor will be forced to do business with the national champion and that may not be efficient. The general principle regarding Adam Smith's "invisible hand" is that if it were more efficient, contractors

would team up. On the other hand, such arrangements may offer the prime contractor savings, innovative manufacturing and management methods, tax exemptions, and new future markets. In many cases, governments are motivated to do business with the foreign contractors with which they already have relationships. Besides, the family of weapon systems approach encourages countries to acquire new weapon systems from the same place because of interoperability and compatibility issues.

The realization of every weapon system program differs in one way or another depending on the situation of the participant countries at that particular time and the objective of the partnership. As with the FLA, participants were trying to introduce a transport aircraft to their services but using European capabilities was a secondary objective. The Eurofighter was also a program that had the same sorts of objectives. These projects may be considered methods to sustain national industrial capabilities. At first glance, this approach may appear harmful to competition, which governments expend a lot of effort to establish. However, in many cases, competition is also established at the sub-contracting. In the 1990s, large contractors had to extricate themselves from several areas of the defense market because of budget decreases. They chose to sub-contract these features and became mainly integrators and niche (or key component) manufacturers. At the sub-contractor level, entering and exiting the market is easier. National goals, meaning political and economic goals, would accommodate sub-contracting from other countries. Thus, competition is global. In a partnership, subcontracting with their industry partners can satisfy the expectation of economic return. Therefore, they may not need to result in a transfer of technology.

In co-development programs, large contractors may become partners and their traditional suppliers may also experience the aforementioned features. In some cases, technology sharing enables national industry to become more capable, and thus be able to access a wider range of markets. Besides, involvement in such a program may benefit the contractor and the sub-contractors by making them more reputable in the market.

In general, although industry gains many benefits from government involvement in international co-development programs, because they are operating in a strictly regulated environment, they may prefer that government influence be progressive. In

many cases, the secondary objectives pursued by governments do not allow industry to find the most efficient relationship or implement the most effective method. Governments, understanding the benefits of disengagement, at least in terms of savings, try to achieve the desired level of decentralization by specifying performance targets rather than dictating detailed design specifications. The JSF is expected to be the exemplar of this new era. Another concern is that contractors may subsidize some cost of the work done for the governments. The defense market is a low profit margin market. In international involvement, the profit margin may even be lower in hopes of future sales. In this case, contractors may not be able to afford assuming some of the costs for the governments.

E. RESEARCH & DEVELOPMENT, BURDEN AND PRODUCTION SHARING

When countries understand the benefits to be received from cooperation, one-issue surfaces immediately. Who is going to get what and what amount will be received from cooperating? This issue is directly related to the secondary goals of the participants.

When the project is in the early stages, nations compare the capabilities they have and then what will be needed to complete the project. It is during this phase that it is likely that new entries will be solicited. The champion nation will try to find a participant who can meaningfully contribute to the program. The search for new participants usually occurs as follows. The nation which creates the idea, usually the champion nation, will introduce it to the other nations within organizations such as NATO. This works like a feasibility report. Then, the champion nation will request a committee be formed with the interested nations. For example, in MEADS, the idea was introduced to the nations within NATO. Then, the interested nations formed a committee to further tailor contractual agreements as well as fitting the concept to their individual requirements. However, in some cases, the champion nation, possessing all the capabilities needed to complete the program, may offer co-development arrangements to the allied countries for marketing reasons. Once a system becomes operational, it will probably remain in service for 25 to 30 years. The system, like a mother hen, will provide the producer work through that period of time. This subject will also be discussed during the production-sharing portion of this section.

When cooperating, participants are motivated to seek further benefits beyond just satisfying a need in their Armed Forces. During the early stages of cooperation, the participant will be competing to receive benefits from the R&D investment. This will provide them with new capabilities, jobs for their citizens during the life of the program and possible future jobs as well as easy access to other weapon systems programs. Working on R&D also provides education/training, expertise for specialists, invites brainpower to the country and exposes the country to new methods and therefore, allowing new applications in other fields. However, because of the nature of R&D it is preferable that R&D investments be conducted in the countries already capable of performing that kind of work. There are many examples about the failures programs faced because all the participants, suitable to do the job or not, were insisting R&D investment occur within their countries. This attitude not only led to wasteful duplication of efforts but also ruined the schedule targets of the program. The first volume of "Handbook of Defense Economics", edited by Keith Hartley and Todd Sandler, specifically focuses on examples within NATO. To prevent such a pitfall, the Eurofighter puts forth the principle that the existing participants should approve every new entrant. This allows the participants to be able to choose countries they feel are politically reliable. Another way to guarantee progress was JFS's simulation-based analysis before the countries became fully committed to the Engineering, Manufacturing and Development phase. A scenario-based simulation is conducted for the candidate nations to find out how many aircraft the nation needs or if the nation needs JSF at all.

R&D work is distributed among participants by requiring subcontracting. There are some examples in which R&D work is conducted with government assets or broken into parts and contracted in house by the government that received that share. However, because the prime contractor who created the winning design will usually be given the production contract, it will also choose a prime contractor early on and encourage or mandate sub contracting is a more efficient way. This method allows performance specs to be used instead of design specs.

After the R&D phase is contracted, participants will be competing for production share. Competition for the production share is expected to be fiercer because participants

in developing countries who did not possess R&D capabilities will be involved. Also, in this phase, new entrants may be expected. It is more likely that developing countries would like to see a stable design before they risk a large amount of money and since this is the only phase in which an economic return can be expected. This phase is also the longest and can be distributed among the participants or among new customers in the form of offsets. This is also the phase, which is monitored much closely for savings and innovation. With this logic, it appears that only during the production phase may significant savings be introduced into the program.

Production is the phase during which more of the participants are expected to compete for a share. Also, the competition is usually over the same or similar products. For example, in an aircraft, annual expenses result from the engine and the avionics. Many countries developed capabilities that resulted in fiercer competition for these parts at the sub contracting level. Also, having the right production share could result in being a logistics center for the system. Thus, infrastructure investment in that country will provide long term jobs, education/training and exposure to the latest technological advances and upgrades related to the system.

As mentioned previously, participants monitor this phase in terms of cost, performance and schedule. Once production begins, it is very difficult and expensive to change the process. The expense will be both in monetary value and schedule. In general, the group will assign a sub-committee to monitor progress and inform the partners. Also, engineering changes represent a challenge. All of the proposed changes must be approved by the participants. Custom requirements will not be introduced to production. Besides, if a proposed change would affect a participant's share in the project, obtaining approval may be very difficult or cause a participant to leave the partnership. Participants may therefore require the project to be conducted under a higher level organization. That fact that Germany and Italy requested the MEADS project be conducted under the auspices of NATO may be a result of such a concern.

In every phase of the program, all participants will be concerned with cost. Since the example projects are development and production programs, cost estimation may not be accurate and is usually lower than actually realized. However, because participant

countries usually plan their budgets yearly, it is necessary for them to know the estimated burden they share. Every project uses a different burden sharing method. Generally most favored method is sharing the burden depending on the percentage of systems participants declare they will acquire. In FLA and the Eurofighter, this same method is also used in production sharing. JSF is structured a little differently. The project defined several phases in which participation levels, certain burden fees and benefits were determined.

Burden sharing may be an issue when one of the countries leaves the program. When Italy left the FLA program, all shares had to be recalculated. This endangers completion of the program, and therefore participants usually request a signed document as a show of intent or as a memorandum of understanding. These documents usually determine the exit criteria. Unless a nation provides an element vital to the project, this particular country's R&D or production shares will disappear if that nation leaves the program. In co-development programs, benefits are directly related to the burden shared. Participants may even cancel the program if a country producing a vital element in the project leaves.

In some cases, the champion nation may volunteer to take on the larger portion of the burden for several reasons. Their priority may be the schedule, since the program may be needed to strengthen an ally or an organization, contribute to achieving a political or economic goal, be the only participant nation with most of the assets needed to complete the project.

The general attitude in R&D, production and burden sharing is to obtain a benefit as much as or close to the amount of the burden shared. In a program, every participant may have different priorities so these issues may be readily solved. On the other hand, because capabilities in developing countries are usually similar, some competition for specific sub contracts should be expected. The biggest problem in international programs is the long decision cycle because participants are cautious and in some cases number of participants may be more than practical. The participant nations must develop adequate communication and a common understanding. This can be achieved by playing with an open deck.

IV. CONCLUSION AND RECOMMENDATIONS

In the 1990's, many nations faced the consequences of economic crisis. A crisis in Japan affected the economy in Italy. The world market established such a network that, as in the chaos theory, a butterfly's peaceful flight in one part of the world may cause a tornado in the other part of the world. In addition, this network is sustained by a computer network, the Internet that never sleeps. The easy and cheap transfer of knowledge has resulted in many opportunities. Companies realized the presence of a global market, which persuaded them to change the methods they used to do business. Many mergers, joint ventures, licensing and sub contracting arrangements were made. In some cases, the governments supported these arrangements and in other cases, Governments forbade. Although Adam Smith's invisible hand shaped and is still shaping the market, the Defense Industry is a special case as Adam Smith also stated. It is not easy to enter the defense market, nor it is easy to leave. National authorities are closely monitoring and influencing this market. In this sense, it is not a free market, and never has been. The balance between supply and demand as well as the circumstances of the supplier and the demander determines the dynamics in a free market. However, political aspects of the defense market caused it to be heavily regulated. On the other hand, production exists in the Defense Industry as in other industries. It was not possible for the industry to disregard the new emerging attitude and opportunities. Production methods, cheaper labor rates, access to new markets or obtaining a larger share from the present market, R&D capabilities and tax issues are some of the opportunities the Defense Industry is willing to pursue.

Also the change in world order may be a result of the new political attitude, or the new attitude may have resulted from the change in the world order. Regardless of how it occurred, the new environment affected the Defense Industry. Organizations such as NATO reviewed their missions, and even the most unthinkable has happened. The lead country of the opposing side is joining de facto the other side's organization. Consequently, the governments had the opportunity to move the massive amount of resources being spent on defense to other areas. The next question was how much to cut.

Many countries later realized that their budget cuts were more than they should have been. Forces needed to be adequately funded in order to be sustained. Also, as regards defense, new, technologically up-and-coming weapons should be introduced into the inventories. Budget cuts mandated that DoD managers use more of the budget for operations and maintenance. This situation jeopardizes the basic concept of the new military; modern, technologically advanced but smaller mobile forces inflicting the least possible collateral damage. This train of thought inspired some ideas such as one aircraft for the Air Force. The idea was that the aircraft would be so technologically advanced that it would be able to fulfill all the missions requested by it. And, as an aside, there would only be one because a country could only afford one system. Of course this is not possible, one item can only be in one place at the same time. Many more than one system are needed for an effective presence throughout the globe. Those systems must have a high enough level of technology to be effective, but most importantly, the opposing force must be deterred from using its weapons. In this sense, the R&D effort is one of the essential strategic assets of the military environment.

For DoD the challenge has been to maintain the needed force level while modernizing it. For industry, survival in a shrinking market depends on being involved in new projects that are highly specialized compared to commercial projects. However, the increasing time between major systems acquisitions is a threat to industry, since the capital acquired from these projects forms the seed money for R&D. Also, R&D is the asset that enables the companies to compete on and obtain new weapons contracts. As we all know, R&D is not cheap.

One traditional approach to development projects was for the government to declare a need and the projected solution to fulfill it. Then, the companies would compete on price since the government provided design would not allow innovation to be introduced into the process other than production methods that could only result in savings. On the other hand, insisting on a strict design many times harmed the programs in terms of cost, performance and schedule. After the 1990s, the Armed Forces, or by generalizing, the government agencies, were no longer the leaders in introducing technology. When the hardships of doing business with the government are considered, it

has been demonstrated that even many traditional contractors were no longer willing to do business with the government. The government then undertook to understand and adapt to the new environment. For this reason, students from about seventy different countries attend the Naval Postgraduate School. Acquisition reforms, and incentive programs were the first solutions the governments implemented to overcome the problem. These solutions addressed continuance of the traditional, independent national defense capability. But, those countries also belonged to organizations, some of which were related to defense. Strategic alliances enabled the nations to think as a group.

Other proposed solutions were not far behind. In the "Handbook of Defense Economics", one of the two editors, Keith Hartley, University of York, proposes an "international specialization based on comparative advantage". That meant participants in a NATO like organization can share the missions and build their Forces to achieve that mission. This idealistic approach does not consider the historical conflicts between the nations belonging to the same organization. In short, every country wants to have an Air Force, so the best solution seems to be cooperating to develop the needed equipment. Then the challenge is to come together and address the common needs as soon as possible. Thus, addressing needs collectively may demonstrate that these needs can be fulfilled in a collaborative way by sharing resources and capabilities, just as in the example projects in this thesis. There are some concerns in following this course, but new solutions are constantly seen that work for all the participants in a program in the latest projects. For example, Dr. Paul G. Kaminski made a statement about the JSF program in the interview published under the name "Reengineering The Acquisition Process" (www.afji.com/mags/1997/june/feat_kaminski.html):

> The JSF management team did a very good job of creating some different models for cooperation, all of which involve 'entry ramps' and 'exit ramps' for participating foreign nations. A country can come in as a full partner or simply as an informed buyer. It costs $10 million to have a seat at the table. That allows a participating nation to get a good view of how the program's requirements are being developed and then to decide if it wants to participate at a greater level or not.

I have found literature addressing the conditions for a successful international cooperation. In the article Gary D. Stephens published under the name "International

Cooperative Programs" (Dudley Knox Library, Database search), he contemplates three considerations that structure the partnership for success. The considerations he addressed are present in the example projects in this thesis and I assume will be concerns in future international co-developments. The first is the existence of a common need. Without communication, nations will not be aware of how common that particular need is. Organizations like NATO are constantly working on that issue. The second consideration is that the program supports the partners' national policies. Nations participate in arrangements or organizations that are politically close to them. For example probability of the U.S. participating in a cooperative program with Iran is very low. Therefore, this is not a big challenge. The third consideration is measuring the program in terms of collaboration versus cooperation. According to G. D. Stephens, collaboration means the partners contribute to the solution rather than simply providing financial resources. If there are too many participants in a collaborative program, the schedule and performance of the program may be harmed because it is harder to agree on a solution when too many are involved in the debate. On the other hand, cooperation may not fulfill the secondary goals of the participants. Mr. Stephens states that he views international cooperative programs as similar to offsets, foreign military sales and international teaming with the exception that international cooperative programs lower the risk of the program being terminated.

The examples in this thesis were chosen from ongoing major weapon systems projects. Every individual project is a further research opportunity. Besides, economic and politic snapshots of the participants can be taken and their effect on the countries' decision as well as how these decisions affected the program may be researched. Things we learned by looking at these programs in this thesis are; number of participants is very important because, the bigger the consortium, the harder to give quick decisions about the trade offs in the program. Participants' economic condition has a large affect on the program. This statement leads to the argument that I made in this thesis, only developed and developing countries will be involved in an international co-development. Programs may address a secondary goal, other than satisfying a military need like sustaining Europe's capabilities in FLA and Eurofighter programs. And also every participant has

secondary goals, usually related to economic return. Participants' priorities may differ, for example schedule may not have the same level of priority in all the participants' agenda. National security may be an issue when technology transfer is considered. Industrial infrastructure determines the suitability of countries for certain parts of the program like some countries may not be suitable to conduct R&D or a part of the production. Technology transfer has a cost. Some participants may be willing to commit more resources to a program than the others. Participants will be pursuing potential economic returns in the program. Burden sharing cannot be considered apart from economic return issues. R&D, production and burden sharing are negotiable issues. Co-development arrangements are one way to get around budget constraints in introducing latest technology to the war fighter. Collective behavior will be awarded by efficiency. Industry is many times willing to work with international partners. Marketing is easier when there is international involvement in the program. Alliances provide a suitable environment for international co-developments. Past experience shows that elasticity in goals, finding common needs and compliance with national policy are the keys to success in an international cooperation. However, one thing should be kept in mind. Every nation keeps the secondary goals in mind when participating in an international program.

In general, international involvement can introduce economies of scale, new contractors/subcontractors and production methods, stability to the program, customers for the weapon system, interoperability and relations between nations that may result in a strategic alliance and cultural exchange.

A major weapon system has the power to change the culture of a force as the F-16 did to many countries after it was added to their inventory. Major weapon systems continue to introduce logistics concepts as well as technology and new methods. As this thesis demonstrates the ever changing world order requires the largest organizations, the Armed Forces, to adapt and adapt quickly. The cost of being late can be enormous. This not only results in a loss of money but also loss of capabilities. Falling budget requires military to find efficient methods to fulfill operational needs.

International co-development efforts are a useful method to meet these needs. They introduce more opportunities than just satisfying the military needs. More co-

developed projects on a larger scale can be expected in every sector, but mainly in the Defense Industry. So Governments should see the benefits of international co-developments and review their policies to adapt. Government contractors, understanding these efficiencies, are already changing their strategies accordingly. Governments must do the same. After all, those who cannot adapt and evolve will perish.

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